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FOREST HEALTH PROTECTION
SOUTH SIERRA SHARED SERVICE AREA

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Subject: **Assessing Insect and Disease Activity within Bald Mountain Project 2012**

Introduction

November 2012, Forest Health Protection was requested to develop maps that would provide assessments of past, current, and projected future tree mortality within the Bald Mountain Project, High Sierra Ranger District, Sierra National Forest. Written discussions based on maps and ground surveys would provide input regarding insect and disease activity within the project. Planning collaborative members could prioritize and develop specific management strategies based on FHP recommendations. While maps are helpful in following long-term patterns of pest-related mortality, other contributing factors and goals should also be considered when developing treatment plans.

Bald Mountain Project is part of the Dinkey Creek Collaborative Forest Landscape Restoration Project 2010, also known as Dinkey Creek CFLR. The CFLR is based on the Pacific Southwest Region leadership intent that larger landscape perspectives are emphasized, revolves around ecological restoration, and incorporates multiple objectives and goals to improve overall forest health. An "All Lands Approach" works across boundaries with multiple partners and cooperators to collaborate scientific-based strategies for ecological restoration and sustainability.

Bald Mountain project is located primarily to the east of Shaver Lake, California (see Appendix A). Portions of the project also occur north and south of the lake, interspersed with private land. Total project evaluates 17,378 acres of federal land, from 5600 to 9700 feet in elevation. Precipitation in this area ranges from 30-50 inches on average depending upon elevation (Appendix B). Most of the lower montane forests (4000-8000 feet) are mixed conifer stands composed of white fir (*Abietium concolor*), California black oak (*Quercus kelloggi*), ponderosa (*Pinus ponderosae*) and sugar (*Pinus lambertiana*) pines, and incense cedar (*Calocedrus decurrens*) (Van Wagtendonk and Fites-Kaufman 2006). Upper montane elevations starting at about 6000 feet, transition into red fir (*Abietinum magnificae*), lodgepole pine (*Pinus contorta*), and Jeffrey pine (*Pinus jeffreyi*) with scattered western white pine (*Pinus monticola*). Quaking aspen (*Populus tremuloides*) are found in meadows or wet areas. Brush species are numerous: manzanita (*Arctostaphylos* species), deer and buck brush and white thorn (*Ceanothus* species), and mountain misery (*Chamaebatia foliolosa*) in addition to conifer saplings.

Mature ponderosa pine plantations are located in various locations in the project, ranging in age from 22 to 57 years old. Canopy cover appeared dense in most areas, most especially in older plantations. Previous thinning and prescribed fire treatments have occurred in various locations within the project.

Observations of insects and diseases

Several insects and diseases were observed in the project area. Field visits to several key locations helped provide an understanding of forest conditions and pest activity. Most bark beetle associated mortality was found in overstocked or dense stands, in trees greater than 12 inches on average. Strong winds from winter storms during 2010 and 2011 exacerbated the situation for already drought-stressed trees vulnerable to beetle attack. Large broken limbs, snapped terminals, and blow-downed trees were prime material for other bark beetles to build populations and add to injury. Root diseases and dwarf mistletoes were common where true fir trees were the majority. No root disease was observed in pines. White Pine Blister Rust (WPBR, *Cronartium ribicola*) infection was estimated to be about 10% on live sugar pines, but losses were seen in all age classes most notably in the legacy-sized pines from a combination of rust and Mountain Pine Beetle (*Dendroctonus ponderosae*).

Western pine beetle (*Dendroctonus brevicomis*) has been particularly active attacking mature ponderosa pines on the district since 2007. Background pockets of bark beetle-associated mortality have begun to coalesce over the landscape, but technically have not reached epidemic levels (Schmid et al. 2007) (Figure 1).

Figure 1. 2010-2011 group mortality caused by Western Pine Beetle in ponderosa pine, Soaproot Saddle area, High Sierra Ranger District.

Figure 2. 2009-2011 mortality caused by Western pine Beetle along an east-facing slope, Nutmeg Saddle ponderosa pine plantations.

However, large groups of dead trees up to 100 or more are easily seen in Blue Canyon – treated and untreated sites (Figure 3). Older plantations of Nutmeg Saddle were especially hit with groups of 20-60 trees annually; new mortality still noted in 2012 aerial surveys (Figure 2). Trees 20 inches and greater were often the center of attacks, then spill over occurred onto adjacent trees. Some group attacks did expand from previous year infestation centers, not surprising as stand conditions was very similar.

Figure 3. 2010 western pine beetle-caused mortality in mature ponderosa plantation along Peterson Mill Road, High Sierra Ranger District.

Within Bald Mountain, aerial surveys over 10 years (Appendix C) indicate that bark beetle associated mortality is still at low levels (less than 5 trees) with a few areas of repeated attacks (3 years consecutively) (Appendix D). On the ground, western pine beetle mortality was found as scattered small groups of ponderosa pines, although some older plantations were found with 20+ trees killed. Attacked trees in plantations or within natural stands had similar characteristics of basal areas greater than 160 ft^2/acre, and greater than 15 inches average diameter at breast height. Plantations viewed near Swanson Meadow were highly overstocked, with remnants of beetle mortality hidden among the trees. Overall tree loss is currently low and therefore not very evident on the ground, but stand conditions have the potential for high mortality if favorable conditions occur for increased bark beetle populations.

True fir trees had the common complex of pests that lead to decline and eventually death. *Heterobasidion occidentale*[1] was found in several old cut fir stumps surrounded by the circle of dead or dying trees that is indicative of a root disease pocket. Infected trees are most often killed off by fir engraver beetle (*Scolytus ventralis*) and woodborers. Fir engraver injury was also seen in dead tops or small tree mortality. Disease centers were not geographically identified during the site visits, but would be recommended to be identified during stand exams.

Dwarf mistletoe (*Arceuthobium* species) is ubiquitous in the Sierra Nevada, both in pines and true firs. At Bald Mountain, various levels of infection were observed, mostly in true firs, as affected branches are subsequently infected by *Cytospora abietis* which kills the entire branch – "flagging." Severe dwarf mistletoe infections contribute to tree decline, predisposing trees further damaging agents. Dwarf mistletoe plants and brooms were noted in branches of understory and overstory trees; bole swellings were also noted in larger trees.

The overall level of white pine blister rust in the project is estimated to be low, but recently dead sugar pines of all size classes were observed. Dead branches or top-kill on dominant sugar pines were assumed to have been caused by blister rust. WPBR infection causing girdling or stunted growth on smaller trees (<6 inches) led to direct mortality – mortality not detected in aerial surveys. Mountain pine beetle galleries were found in dead trees greater than 12 inches, but trees could not be determined to have had a prior WPBR infection. Mortality associated with MPB is most likely a combination of WPBR, drought, and overcrowded conditions in the stand.

Forest Health Discussion

Maps of risk and annual aerial detection surveys are useful tools for understanding and following pest trends over the landscape. Aerial detection surveys are conducted on an annual basis, only reporting fading trees attacked the previous year. This survey does miss trees currently infested, and understory trees that do not have significant crown signatures (trees smaller than 9 inches) as they are not visible from the air at 1000 ft above ground level. Risk maps are generated using several vegetation base layers (Forest Inventory Analysis data, EVEG, and CA-GAP) then simulating the impact that critical factors will have on the risk of tree mortality within the vegetation layers. Input criteria for the models include: stand density index (SDI), basal area (BA), quadratic mean diameter (QMD), precipitation, relative humidity, elevation, percent canopy cover, temperature regime, among others. Scientific literature, professional collaboration, and statistical data form the basis for the development of the host-specific models. Model criteria and parameters vary across the landscape for each host type.

[1] also known as S-type annosum, formerly *H. annosum*

The 2012 bark beetle risk map[2] generated for the Bald Mountain project shows that a large majority of estimated basal area loss is in the 26-50% category (Appendix E). The potential of basal area loss is highest for ponderosa pines and firs lost to beetles, and white pines (sugar and western white) lost to white pine blister rust and beetles. Risk ratings of 51% and above fall just outside of project boundaries within the buffer zones along Pitman Creek and South Fork Pitman. Polygons with repeated mortality (Appendix D) were less than 1% of total project area. These sites can be further reviewed by Forest Health Protection in 2013 to determine possible causes of repeated mortality, but most likely due to stand conditions that are conducive for bark beetle infestation.

Overstocked, dense, or stagnant stands are at the highest risk for bark beetle attack (Oliver 1995, Oliver and Uzoh 1997, Fettig et al. 2007). Stand density index (SDI) is often used to determine risk from disturbance agents. According to Oliver (1995) pine stands in California with basal areas greater than 230 SDI (150 ft^2/acre) are at imminent risk for mortality due to bark beetles and will experience mortality if the SDI rises. Stands with very high stand basal areas or density indexes consistently experience the highest levels of bark beetle associated mortality (Hayes 2009). These significant mortality events may even lower the SDI back to threshold range (Oliver and Uzoh 1997).

Current stand inventories of Bald Mountain reveal that two thirds of plots are above this basal area threshold. To reduce the risk of bark beetle outbreaks Long and Shaw (2005) recommend thinning targets of 55-60% of SDI max for Sierra mixed-conifer stands. Half of inventoried plots on Bald Mountain were over their respective 50% maximum SDI (both pine and red fir stands, therefore are considered at risk for infestation. This is confirmed on Insect and Disease Risk Map using the same criteria (Appendix E). Current proposed treatments to reduce stand density and stocking are supported by Forest Health Protection as they coincide with bark beetle prevention recommendations (Fettig 2012, Fettig et al. 2007).

Silvicultural options and prioritizing of individual units can be determined based on which units have higher risk. Stands with low basal area or density indexes have been shown to experience less mortality over the long-term (Fettig 2012). This is most likely due to reduced resource and water competition between trees, which deteriorate tree vigor and weaken resistance against damaging agents. GTR 220 (North et al. 2009) includes topography to gauge optimal conditions for growth: trees on south or east-facing slopes may require wider spacing to accommodate drier site conditions while north-faces or cold drainages can accommodate higher stocking levels.

Sanitation or salvage of currently infested or dead trees will not have a huge impact on reducing local beetle populations. Removal of only a few trees will not significantly alter susceptible stand conditions. Prescribed fire is a very useful tool for restoration and prevention efforts. However, great care should be considered in timing and proper application to prevent excessive fire injury which can predispose affected trees to subsequent beetle attacks (Parker et al. 2006). Follow-up monitoring on all treatments is critical to gauging effectiveness and success.

Reduction of host types where disease centers are identified can reduce infection distribution, above and below ground. *H. occidentale* is the most common root disease found in California of predominantly true fir stands. Along the western side of Sierra Nevada in lower montane forests, infections are ubiquitous. Size and frequency of infections do vary, and stands with more species diversity are often less likely to have large infection centers. Treatments that are focused on reducing intra-species root-to-root contact, altering

[2] Disease risk maps are unable at this time.

structure or age class to increase stand heterogeneity, or preventing new infection centers will mitigate the impact of *H. occidentale* on the landscape. Additionally, if cut stumps are not promptly treated with an approved borate product to prevent new infection centers developing, thinning treatments will do more harm than good in the long run.

White pine blister rust is highly pathogenic on white pines (sugar and western white), but mortality rates can vary by individual tree. Small diameter trees appear most vulnerable and die a few years after infection. As a shade-intolerant species, overstory suppression and overcrowding are also factors that have appeared to contribute to regeneration mortality. Larger trees can self-prune infected branches, but still weaken from bole cankers. Dead topped trees are typically a sign of bole infection in the leader; these are often mass-attacked by mountain pine beetle by the next year. Restoration efforts are needed to preserve white pines in Sierra Nevada. Gap creation and planting of rust-resistant sugar pine stock is strongly recommended as a management tool to help these beleaguered species. Nursery efforts are still on-going to develop better resistant stock against WPBR, but progress is slow and virulent mutations of WPBR have shown up in other parts of the Sierras.

Most bark beetles and pathogens encountered in the Sierra Nevada are native pests; therefore management treatments are only intended to reduce the potential for large-scale infestation. These pests are tightly co-evolved with their host plants which in turn rely on agents as natural forest disturbances for continued survival and ecosystem stability. The goal of integrated pest management is to not stop trees from dying, but rather mitigate large-scale mortality that contributes to high-fuel loads or public safety hazards. Density reduction treatments will not eliminate the potential for insect attacks or self-thinning. Tree mortality will continue to occur over the landscape regardless, but treatments are designed to create healthier conditions to improve stand resistance and resilience before disturbance events. Dead trees provide wildlife habitat, forage, and nesting opportunities; soil nutrient recycling; and diversity in forest composition and structure. Dead trees are a critical component to forest ecosystems as much as live green trees. Snags can be created if the distribution of snags on the landscape does not meet project needs; however, snag creation should be undertaken carefully to avoid unintended tree mortality. Forest Health Protection can work with land managers to discuss opportunities for snag creation.

Climate change can be a significant factor when considering the behavior of insects and distribution of diseases. Abiotic and biotic disturbances are all affected by changes in temperature and precipitation. Insect behavior is particularly are determined by fluctuations in weather patterns: their flight timing, reproductive success, or host availability are influenced by the rise and fall of temperature. Drought events often trigger increased bark beetle activity in California (Ferrell 1996, Smith 2007) and when populations are high, mortality will occur across variable stocking regimes. Indirect and direct consequences will occur due to climate change, and those changes can be increasing or decreasing pest activity (Dale et al. 2001). Insect risks displayed on the Risk Map are estimations that can quickly alter if conditions change beyond model predictions. *Heterobasidion* appears more aggressive when hosts are stressed that incidence and spread could increase with future climate regimes (Kliejunas et al. 2009). Dwarf mistletoe infection is also predicted to intensify and become more widespread if droughts become more frequent and severe (Kliejunas et al. 2009).

Thank you including Forest Health Protection as part of the Bald Mountain collaborative process. Please contact us if you have any additional questions or concerns regarding this report or pests in general, we are happy to assist.

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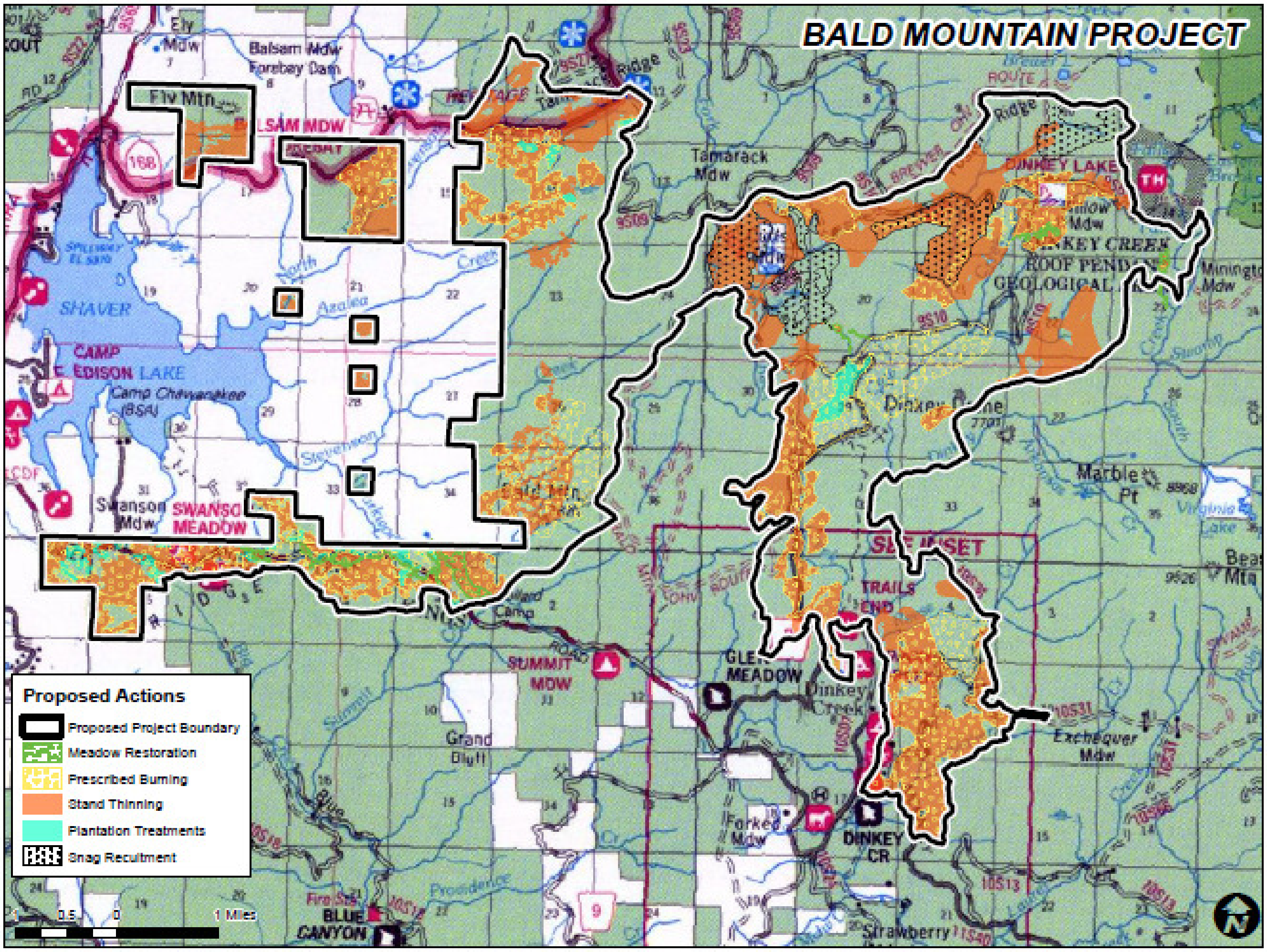
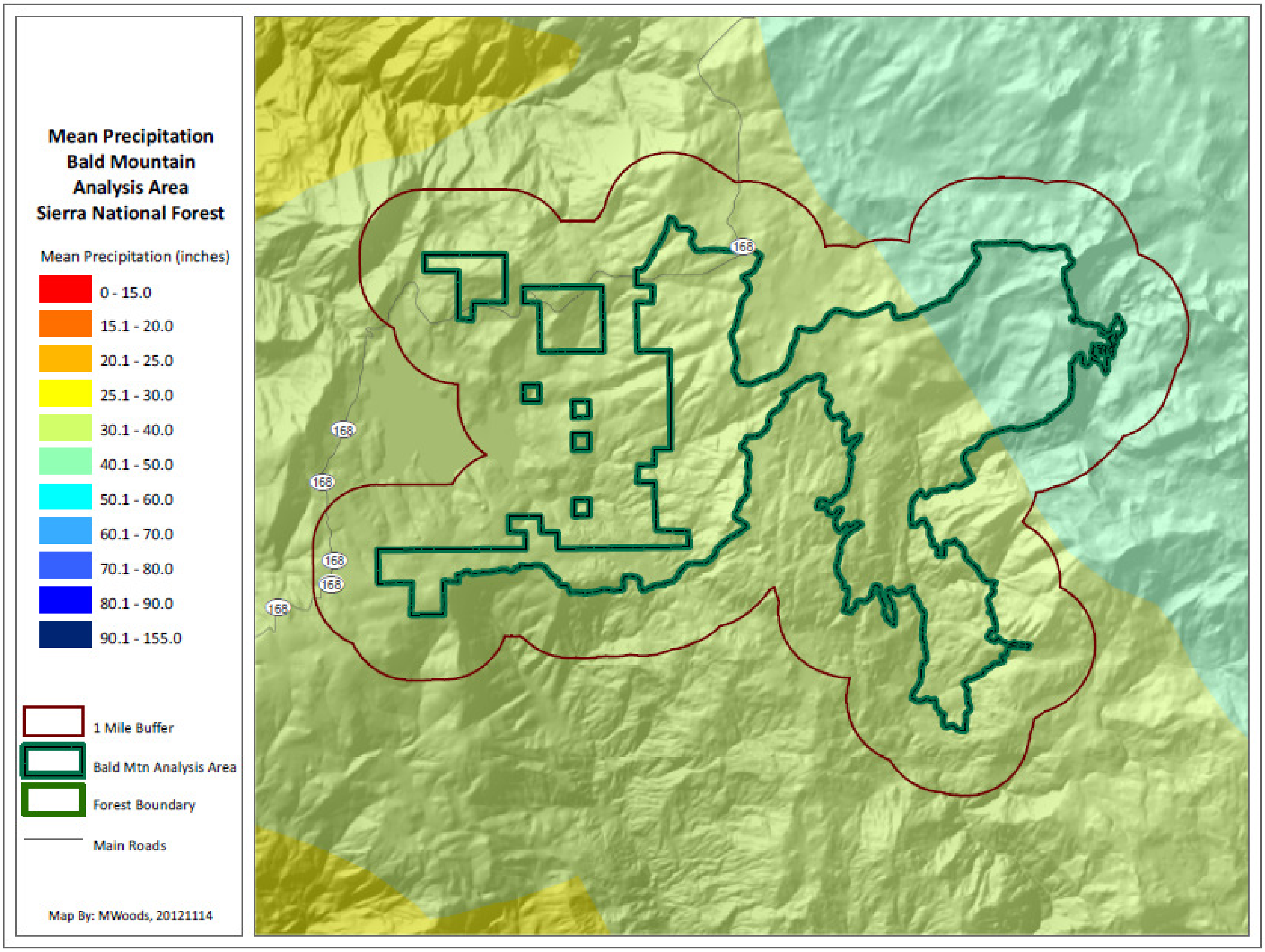
List of Appendixes

Appendix A. Map of Bald Mountain Project Area, High Sierra Ranger District, Sierra National Forest.
Map courtesy of High Sierra Ranger District.



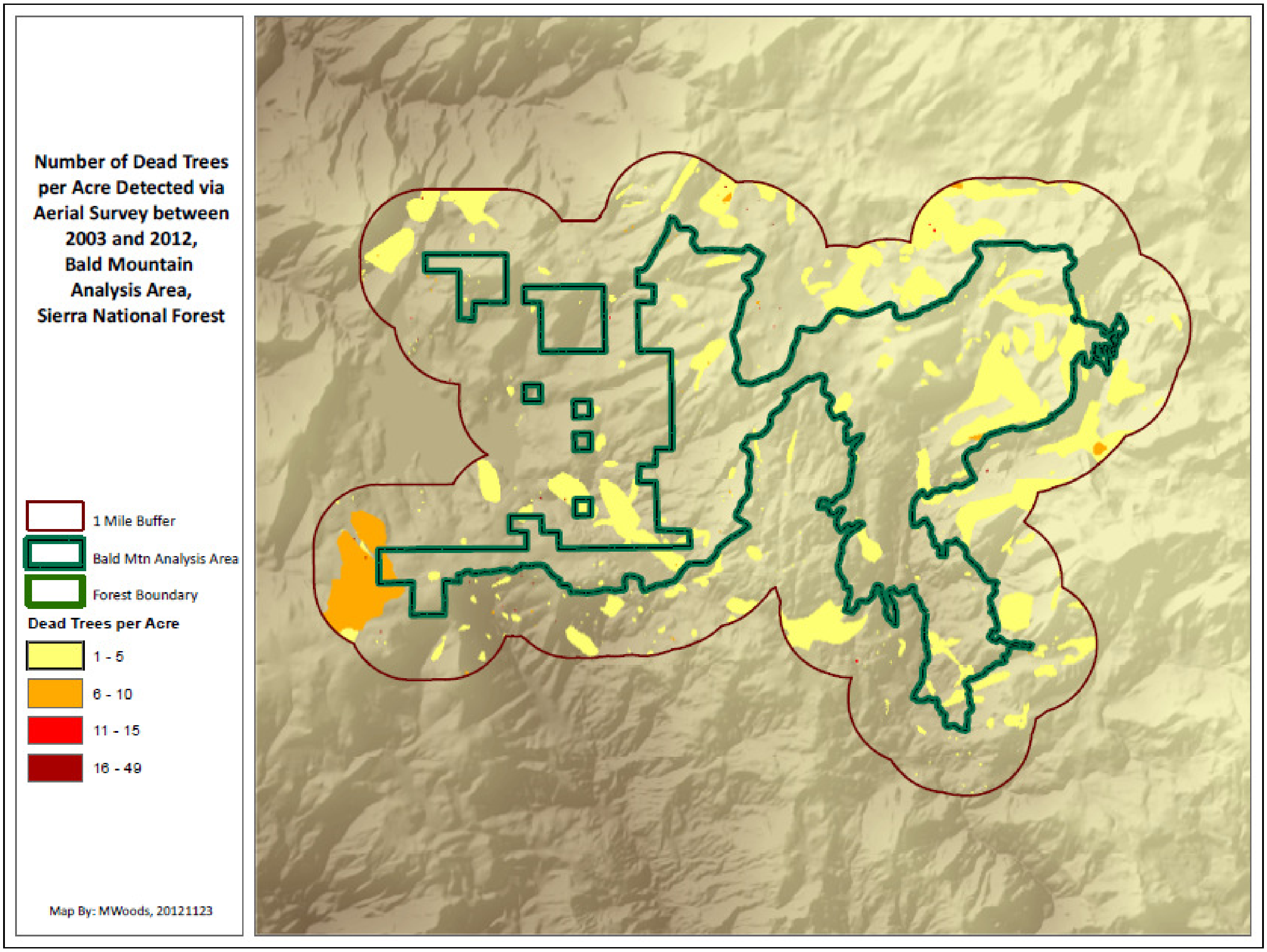
Appendix B. Mean Precipitation Map of Bald Mountain Project Area.

Map courtesy of Forest Health Monitoring, Davis, CA.

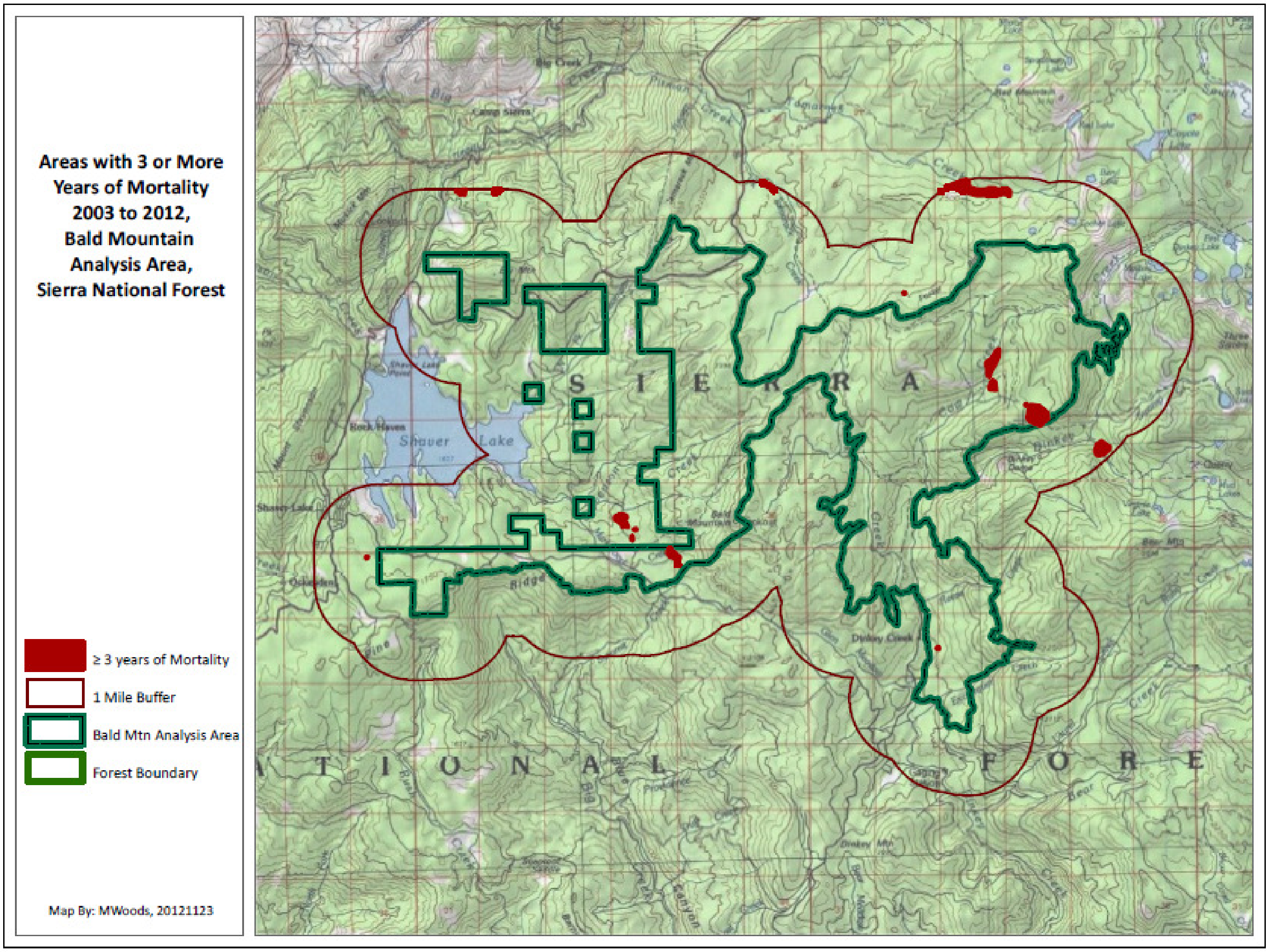


Appendix C. Summarized map of tree mortality detected from FHM Aerial Surveys 2003-2012 over Bald Mountain Project Area.

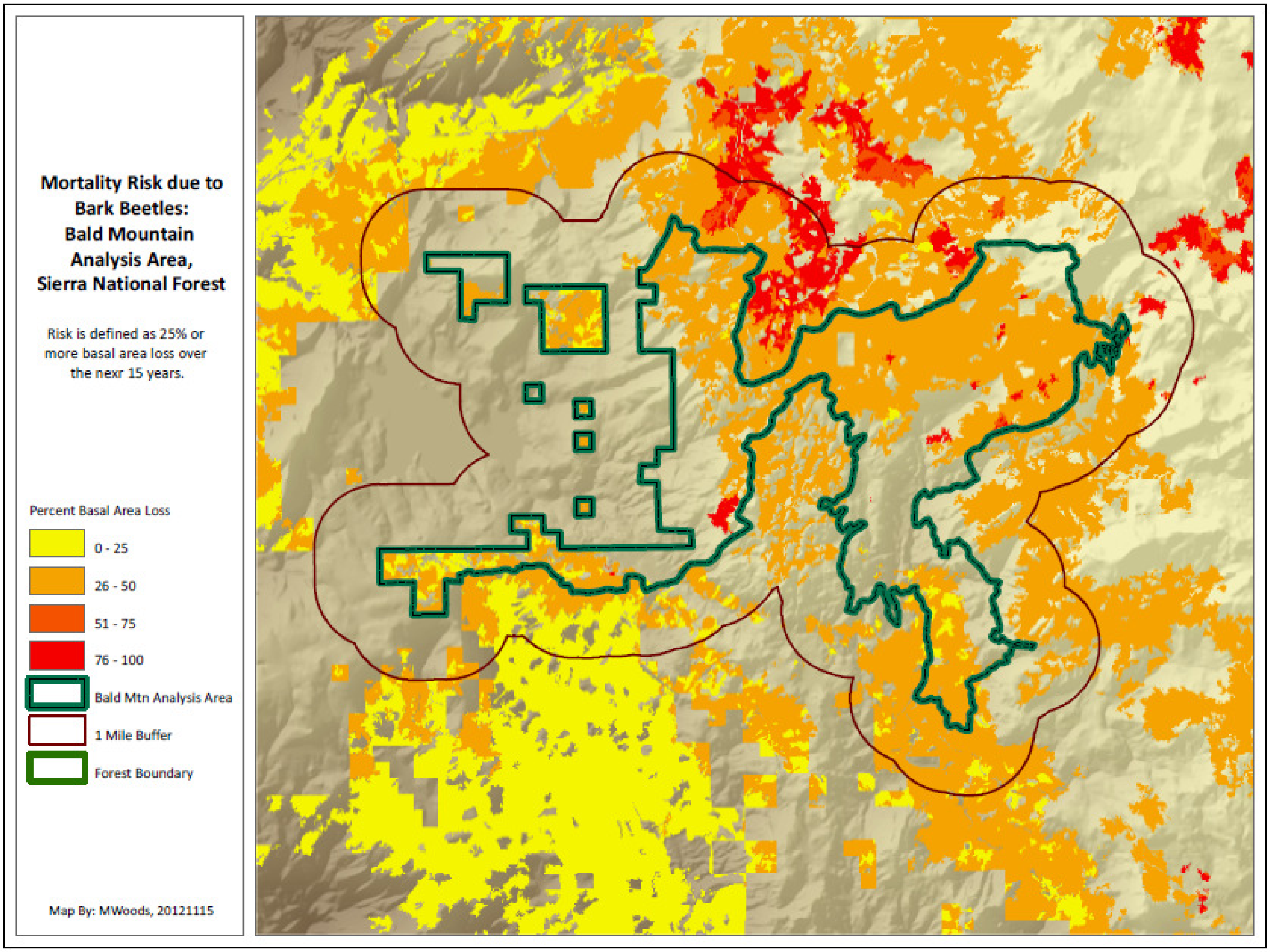
Map courtesy of Forest Health Monitoring, Davis, CA.



Appendix D. Map of areas with 3 years or more of tree mortality within Bald Mountain Project Area.
Map courtesy of Forest Health Monitoring, Davis, CA.



Appendix E. 2012 Insect Risk Map of Bald Mountain Project area.
Map courtesy of Forest Health Monitoring, Davis, CA.



Appendix F. Forest pests and diseases of concern

Forest pests and disease of concern are listed in alphabetical order, below. These pests and diseases are primarily of concern when they reach levels beyond the natural range. Excessive tree densities are a cause for concern, as reduced individual tree vigor allows many pests and diseases to prosper. Forest pests and diseases are natural regulating agents and become a primary concern when they cause larger affects than are considered acceptable. Large scale die-off or mortality from forest pests or diseases can create fuels conditions that have the potential to create catastrophic wildland fire. Another cause for concern is excessive damage created by forest pests and diseases that reduces their commercial value. The species below are not inclusive of all pests or diseases that might affect the project area, but rather the ones listed are those that can have un-desirable effects.

This section details tree species affected that are present in the project area (the pests may affect species other than those listed, however only those tree species in the project area are listed). The management options are addressed and come directly from Pests of the Native California Conifers (Wood et al, 2003). Other information regarding these pests and diseases is available in that publication, as well as numerous others. This report is intended to address management options as this information will assist the Deciding Official and managers. In most cases, wording is directly from the above mentioned publication, with minor changes. The tense for this section is inconsistent with the rest of the document, and is in present tense. This is to maintain consistency with the publication from which the management options were taken, and to avoid confusion in reading.

Identification of forest pests and disease in this section requires some training, and field personnel implementing prescriptive management recommendations should be trained to identify specific diseases so management recommendations can be implemented.

Heterobasidion root disease (Heterobasidion occidentale (S-type) and H. irregular (P-type))
Species affected: Jeffery pine, ponderosa pine, sugar pine, white fir, red-fir

Significance: In California, this disease is widespread and damaging to nearly all native conifer species. Because the fungus is known to invade freshly cut stumps, spread and intensification of the disease have increased with timber harvesting and intensive forest management. Once infected, the fungus persists in the roots and the soil for many years. Pines suffer the greatest impact as enlarging centers of infection progressively kill tress or render them susceptible to insect attack, especially bark beetles. Moisture stress, insects, and, in some cases, air pollution contribute to the severity of damage caused by *Heterobasidion*. Firs and other species are not often killed but are weakened, decayed, and made susceptible to uprooting and attack by insects, especially bark beetles. Infected trees in high-use areas pose a hazard to life and property.

Management options: Prevention of infection and spread is the best way to manage *Heterobasidion* root disease of conifers, especially pines. Cut stumps would be treated with borax-based registered chemicals. Thinning of eastside pines during warm, dry periods in summer inhibits fungal growth, and consequently, tree infection. With conifer species other than pines, prevention of wounds, especially in the lower trunk, is the best way to avoid infection.

<u>Dwarf mistletoes (*Arceuthobium* spp.)</u>
Species affected: All conifers (but host specific)

Significance: In California and throughout much of the West, dwarf mistletoes are considered among the most damaging forest disease agents. Mortality, growth reduction, poor wood quality, reduced seed production and hazardous trees are the consequences of infected forest stands. Infected trees and stands are also predisposed to insect infestation, especially bark beetles and other diseases, particularly during periods of drought or other tree stress.

Management options: Dwarf mistletoes are obligate parasites. Therefore, mistletoe dies when the infected part of the host dies or is removed. In the forest various combinations of harvesting of infected trees, thinning, favoring non-susceptible hosts, and pruning have been used to reduce losses from dwarf mistletoes. Eradication of the pest is not necessary. Keeping the disease at low to moderate levels in the forest is usually enough to prevent unacceptable damage. Highly valued trees, or trees in high use areas, will require greater levels of management to reduce loss or to minimize hazards.

<u>Fir Engraver (Scolytus ventralis)</u>
Species affected: True firs

Significance: Trees weakened by root disease, especially *Heterobasidion* root disease, dwarf mistletoe, high stand density and drought are infested by Fir Engraver. Extensive mortality in northern California was related to the extreme drought of 1987-1992. Trees killed during this drought are especially notable in the lower elevations, mixed conifer types.

Management options: Lower stand density will promote rapid growth of the residual stand. In root-diseased areas, stands can be converted to species not susceptible to *Heterobasidion* root disease. In urban areas, infested trees should be felled and broods killed by removing and destroying the bark. High-risk trees can be removed by infestation by this beetle.

<u>Jeffery Pine Beetle (*Dendroctonus jefferyi*)</u>
Species affected: Jeffery pine

Significance: This bark beetle is the principle insect pest of overmature and mature Jeffrey pine. Young trees over 12 inches in diameter are also frequently killed. Like Mountain Pine Beetle, Jeffrey Pine Beetle prefers to colonize trees weakened by lightning, disease, fire, wind or drought.

Management options: As with other species of bark beetles, removal of weakened trees before infestation by this species will lower the risk of high-level tree mortality. Removing infested trees before emergence of Jeffery pine beetle in June may lower the risk of future infestations. Insecticides can be applied to the bark of highly valued trees to prevent infestation.

<u>Mountain Pine Beetle (*Dendroctonus ponderosae*)</u>
Species affected: ponderosa pine, lodgepole pine, sugar pine, western white pine

Significance: Mountain Pine Beetle is the principal insect pest of mature and decadent ponderosa pine and sugar pine, although younger trees, from 4 to 5 inches in diameter can be killed. Mountain Pine Beetle typically colonizes trees weakened by lightning, fire, wind and drought. Outbreaks of this bark beetle can kill millions of trees covering many hectares.

Management options: As with other species of bark beetles, removal of trees weakened by drought, competition, dwarf mistletoe, root disease, fire and wind before infestation by Mountain Pine Beetle will lower the risk of high-level tree mortality. Removing infested trees before emergence of this bark beetle in June may lower the risk of future infestations. Insecticides can be applied to the bark of highly valued trees to prevent infestation.

<u>Engraver Beetles (*Ips* species)</u>
Species affected: Ponderosa, Jeffrey, Sugar, Western white, lodgepole

Significance: At outbreak levels, engravers can cause considerable tree mortality and, thus, it is an important pest in timber-producing regions. Outbreaks are usually shot-lived, not lasting more than one year, although outbreaks have been known to last two to three years during periods of extreme drought. Population densities of this engraver beetle can increase in logging debris, leading to the infestation of nearby living trees. Trees with tops killed by engravers are often subsequently killed by Western Pine Beetle, Mountain Pine Beetle, or Jeffery Pine Beetle.

Management options: Cut and scatter branches from treetops remaining after logging. Exposure to the sun will kill broods beneath the bark. Insecticides can be applied to the bark of highly valued trees to prevent infestation

<u>Red Turpentine Beetle (*Dendroctonus valens*)</u>
Species affected: Jeffery pine, ponderosa pine, sugar pine, western white pine

Significance: Red Turpentine Beetle is attracted to wounded trees and freshly cut stumps, which release certain turpenes hydrocarbons attractive to this insect. Trees attacked over the course of several years are weakened but rarely killed by Red Turpentine Beetle. Rather, attacked trees are more frequently killed by Western Pine Beetle (ponderosa pine) and Mountain Pine Beetle (sugar pine and ponderosa pine). Stumps are readily infested and may produce populations that attack nearby living trees. Red Turpentine Beetle attacks are often associated with pines infected with black stain root disease.

Management options: Avoid wounding trees. A pesticide may be applied to the bark on the lower trunk of highly values trees to prevent further attacks by Red Turpentine Beetle and lower the risk of tree mortality caused by *Dendroctonus* spp. and *Ips* species.

Western Pine Beetle (*Dendroctonus brevicomis*)
Species affected: ponderosa pine

Significance: Western Pine Beetle is the most destructive insect pest of ponderosa pine in California, infesting trees weakened by smog, *Heterobasidion* root disease, fire, drought and lightning. Dead trees may appear singly or in small groups when Western Pine Beetle attacks at low population levels. At high population levels, groups of 10-20 trees are killed.

Management options: Stand management practices such as thinning and maintaining a mixture of species help mitigate against the high-level tree mortality associated with large areas of dense, mature pines. Insecticides can be applied to the bark of highly valued trees to prevent infestation.

White fir (true) mistletoe (*Phoradendron pauciflorum*)
Species affected: white fir

Significance: In general, white fir mistletoe is a problem only in the larger, older firs in a stand. Young or small trees are seldom infected. Growth reduction resulting from intensive infection and, eventually top dieback are the greatest impacts of this mistletoe. Often insects are responsible for death of the badly weakened tops. Reduction of cone crops and decay entering the trunk from dead tops are also significant losses attributable to white fir mistletoe. Some trees die as a result of extensive mistletoe infection and insect attack, particularly during years of drought.

Management options: Because white fir mistletoe is spread by birds, prevention of the disease in native stands is not practical. Young trees are seldom seriously affected by this mistletoe. Older, heavily infected firs should be harvested before they are killed by insects, drought, or a combination of both. Trees with dead and dying tops will in time undergo extensive trunk decay unless they are harvested. No chemical control is available, and pruning infected branches is not practical.

White Pine Blister Rust (*Cronartium ribicola*)
Species affected: 5-needled pines

Significance: White pine blister rust is the most damaging disease of pines and has cost more to control than any other forest disease in North America. In California alone, millions of trees are damaged or killed each year, and millions of dollars have been spend, probably fruitlessly, on control through eradication of *Ribes* spp. Small trees are particularly vulnerable: only a few branch infections or a single trunk infection can result in tree death. Larger infected trees can also be severely weakened and eventually die or are killed by bark beetles.

Management options: *Ribes* spp. Eradication has been discontinued as an effective method of controlling blister rust. Growth of nonhost species on high rust hazard sites is encouraged. Current research and development of rust-resistant pines may lead to a valuable management option in the near future.

*** This blister rust has 4 life stages and requires ideal conditions to pass between the host (sugar pine) and alternate host (Ribes, Castilleja). Humidity and temperature requirements are very specific for the basidiospore stage and basidiospores do not travel far. The basidiospore is the diploid stage of White Pine Blister Rust, and so if this cycle is not complete, 'infection' does not occur.*